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HOW TO DESTROY RATS.

BY

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF BIOLOGICAL SURVEY,
Washington, D. C., June 25, 1909.

SIR: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a report by David E. Lantz, an assistant in the Biological Survey, on How to Destroy Rats. It is in the main a digest of Bulletin 33 of this bureau, now out of print, and is intended to meet the numerous requests from all parts of the country for practical directions for ridding communities of these destructive rodents. If the importance of rat-proof construction in building and the necessity of depriving rats of food were generally understood, the measures adopted for their destruction would be far more successful.

Respectfully,

C. HART MERRIAM,
Chief, Biological Survey.

Hon. JAMES WILSON,
Secretary of Agriculture.

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HOW TO DESTROY RATS.

INTRODUCTION.

The brown or Norway rat (*Mus norvegicus*) is the worst mammal pest in the United States, the losses from its depredations amounting to many millions of dollars yearly—to more, probably, than the losses from all other injurious mammals combined.[a] In addition to its destructive habits, this rat is now known to be an active agent in disseminating infectious diseases, a fact which renders measures for its destruction doubly important.

FIG. 1.—Brown rat.

Introduced into America about 1775, the brown rat has supplanted and nearly exterminated its less robust relative, the black rat, and despite the incessant warfare of man has extended its range and steadily increased in numbers. Its dominance is due to its great fecundity and its ability to adapt itself to all sorts of conditions. It

[a] Several species of rats are known as house rats, including the black rat (*Mus rattus*), the roof rat (*Mus alexandrinus*), and the brown rat (*Mus norvegicus*). Of these, the last is the commonest and most widespread in this country. Not one of these species is a native, but all were imported from the Old World. As their habits in general are similar, the instructions given in the bulletin apply alike to all.

breeds three, four, or even more, times a year, and produces from 6 to 17 young in a litter. Females breed when only 4 or 5 months old. The species is practically omnivorous, feeding upon all kinds of animal and vegetable matter. It makes its home in the open field, the hedge row, and the river bank, as well as in stone walls, piers, and all kinds of buildings. It destroys grains when newly planted, while growing, and in the shock, stack, mow, crib, granary, mill, elevator, or ship's hold, and also in the bin and feed trough. It invades store and warehouse, and destroys furs, laces, silks, carpets, leather goods, and groceries. It attacks fruits, vegetables, and meats in the markets, and destroys by pollution ten times as much as it actually eats. It carries disease germs from house to house and bubonic plague from city to city. It causes disastrous conflagrations; floods houses by gnawing lead water pipes; ruins artificial ponds and embankments by burrowing; destroys eggs and young poultry; eats the eggs and young of song birds and game birds; and damages foundations, floors, doors, and furnishings of dwellings.

MEANS OF REPRESSING RATS.

Rats have developed so much intelligence and such extraordinary caution that attempts to exterminate them have rarely succeeded. The failures have been due not so much to lack of effective methods as to the neglect of certain precautions and the absence of concerted action. We have rendered our work abortive by continuing to provide subsistence and hiding places for the rats. When these advantages are denied, persistent and concerted use of the methods here recommended will prove far more effective.

RAT-PROOF BUILDING.

First in importance, as a measure of rat repression, is the exclusion of the animals from places where they find food and safe retreats for rearing their young.

The best way to keep rats from buildings, whether in city or in country, is by the use of cement in construction. As the advantages of this material are coming to be generally understood, its use is rapidly extending to all kinds of buildings. Dwellings, dairies, barns, stables, chicken houses, ice houses, bridges, dams, silos, tanks, cisterns, root cellars, hotbeds, sidewalks, and curbs are now often made wholly of cement. The processes of mixing and laying this material require little skill or special knowledge, and workmen of ordinary intelligence can successfully follow the plain directions contained in handbooks of cement construction. Illustrated handbooks are often furnished free by cement manufacturers.

Many modern public buildings are so constructed that rats can find no lodgment in the walls or foundations, and yet in a few years,

through negligence, such buildings often become infested with the pests. Sometimes drain pipes are left uncovered for hours at a time. Often outer doors, especially those opening on alleys, are left ajar. A common mistake is failure to screen basement windows which must be opened for ventilation. However the intruders are admitted, when once inside they intrench themselves behind furniture or stores, and are difficult to dislodge. The addition of inner doors to vestibules is an important precaution against rats. The lower part of outer doors to public buildings, especially markets, should be reenforced with light metal plates to prevent the animals from gnawing through.

Dwellings.—In constructing dwelling houses the additional cost of making the foundations rat-proof is slight as compared with the advantages. The cellar walls should have concrete footings, and the walls themselves should be laid in cement mortar. The cellar floor should be of medium rather than lean concrete, and all water and drain pipes should be surrounded with concrete. Even old cellars may be made rat-proof at comparatively small expense. Rat holes may be permanently closed with a mixture of cement, sand, and broken glass, or sharp bits of crockery or stone.

On a foundation like the one described above, the walls of a wooden dwelling also may be made rat-proof. The space between the sheathing and lath, to the height of about a foot, should be filled with concrete. Rats can not then gain access to the walls, and can enter the dwelling only through doors or windows. Screening all basement and cellar windows with wire netting is a most necessary precaution.

Old buildings in cities.—Aside from old dwellings, the chief refuges for rats in cities are sewers, wharves, stables, and outbuildings. Modern sewers are used by the animals merely as highways and not as abodes, but old-fashioned brick sewers often afford nesting crannies.

Wharves, stables, and outbuildings in cities should be so built as to exclude rats. Cement is the chief means to this end. Old tumble-down buildings and wharves should not be tolerated in any city.

In both city and country, wooden floors of sidewalks, areas, and porches are commonly laid upon timbers resting on the ground. Under such floors rats have a safe retreat from nearly all enemies. The conditions can be remedied in towns by municipal action, requiring that such floors should be replaced by others made of cement. Areas or walks made of brick are often undermined by rats, and may become as objectionable as those of wood. Wooden floors of porches should always be well above the ground.

Farm buildings.—Granaries, corncribs, and poultry houses may be made rat-proof by a liberal use of concrete in the foundations and floors; or the floors may be of wood resting upon concrete. Objection

has been urged against concrete floors for horses, cattle, and poultry, because the material is too good a conductor of heat, and the health of the animals suffers from contact with these floors. In poultry houses, dry soil or sand may be used as a covering for the cement floor; and in stables, a wooden floor resting on the concrete is just as satisfactory so far as the exclusion of rats is concerned.

The common practice of setting corncribs on posts with inverted pans at the top often fails to exclude rats, because the posts are not high enough to place the lower cracks of the structure beyond reach of the animals. The posts should project at least 3 feet above the surface of the ground, for rats are excellent jumpers. But a crib built in this manner, though cheap, is unsightly.

For a rat-proof crib, a well-drained site should be chosen. The outer walls, laid in cement, should be sunk about 20 inches into the ground. The space within the walls should be thoroughly grouted with cement and broken stone and finished with rich concrete for a floor. Upon this the structure may be built. Even the walls of the crib may be concrete. Corn will not mold in contact with them, provided there is good ventilation and the roof is water-tight.

However, there are cheaper ways of excluding rats from either new or old corncribs. Rats, mice, and sparrows may be effectually kept out by the use of either an inner or an outer covering of galvanized-wire netting of half-inch mesh and heavy enough to resist the teeth of rats. The netting in common use for screening cellar windows is suitable for covering cribs. As rats can climb the netting, the entire structure must be screened.

KEEPING FOOD FROM RATS.

The effect of an abundance of food on the breeding of rodents should be kept in mind. Well-fed rats mature quickly, breed often, and have large litters. Poorly fed rats, on the contrary, reproduce less frequently and have smaller litters. In addition, scarcity of food makes measures for destroying the animals far more effective.

The general rat-proofing of buildings is the most important step in limiting the food supply of rats. But since much of the animals' food consists of garbage and other waste materials, it is not enough to bar rats from markets, granaries, warehouses, and private food stores. Garbage and offal of all kinds must be so disposed of that rats can not obtain them.

In cities and towns an efficient system of garbage collection and disposal should be established by ordinances. Waste from markets, hotels, cafés, and households should be collected in covered metallic receptacles and frequently emptied. Garbage should never be dumped in or near towns, but should be utilized or promptly destroyed by fire.

Rats find abundant food in country slaughterhouses; reform in the management of these is badly needed. Such places are centers of rat propagation. It is a common practice to leave offal of slaughtered animals to be eaten by rats and swine, and this is the chief means of perpetuating trichinæ in pork. The law should require offal to be promptly cremated or otherwise disposed of. Country slaughterhouses should be as cleanly as constantly inspected abattoirs.

Another important source of rat food is the remnants of lunches left by employees in factories, stores, and public buildings. This food, which alone is sufficient to attract and sustain a small army of rats, is commonly left in waste baskets or other open receptacles. Strictly enforced rules requiring all remnants of food to be deposited in covered metal vessels would make trapping far more effective.

If buildings are infested with rats, wire-screened compartments should be used for storing food. Many merchants now keep flour, seeds, meats, and the like in wire cages, and the practice should be general. Ice boxes and cold-storage rooms may be made proof against rats by an outer covering of heavy wire netting of half-inch mesh. Steamboat companies engaged in carrying high-priced southern produce to northern markets can, at small expense, protect the vegetables or fruits in screened compartments on both docks and vessels.

Rats do not gnaw the plane surfaces of hard materials, such as wood. They attack doors, furniture, and boxes at the angles only. This fact suggests the feasibility of protecting chests containing food by light coverings of metal along the salient angles. This plan has for years been in use to protect naval stores on ships and in warehouses.

NATURAL ENEMIES OF RATS.

Among the natural enemies of rats are the larger hawks and owls, skunks, foxes, coyotes, weasels, minks, dogs, cats, and ferrets.

Probably the greatest factor in the increase of rats, mice, and other destructive rodents in the United States has been the persistent killing off of the birds and mammals that prey upon them. Animals that on the whole are decidedly beneficial, since they subsist upon harmful insects and rodents, are habitually destroyed by some farmers and sportsmen because they occasionally kill a chicken or a game bird.

The value of carnivorous mammals and the larger birds of prey in destroying rats should be more fully recognized, especially by the farmer and the game preserver. Rats actually destroy more poultry and game, both eggs and young chicks, than all the birds and wild mammals combined; yet some of our most useful birds of prey

and carnivorous mammals are persecuted almost to the point of extinction. An enlightened public sentiment should cause the repeal of all bounties on these animals and afford protection to the majority of them.

DESTRUCTION OF RATS.

The Biological Survey has made numerous laboratory and field experiments with various agencies for destroying rats. The results form the chief basis for the recommendations set forth in the following pages.

Traps.

Owing to their cunning it is not easy to clear premises of rats by trapping; if food is abundant, it is impossible. A few adults refuse

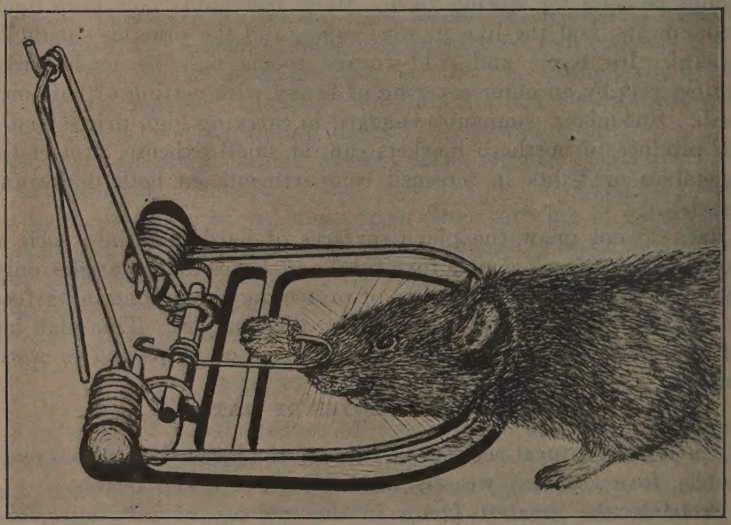

FIG. 2.—Method of baiting guillotine trap.

to enter the most innocent-looking trap. And yet trapping, if persistently followed, is one of the most effective ways of destroying the animals.

Guillotine trap.—For general use the improved modern traps with a wire fall released by a baited trigger and driven by a coiled spring have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called "guillotine" traps, are of many designs, but the more simply constructed are preferable. Probably those made entirely of metal are the best,

as they are more durable and are less likely to absorb and retain odors.

Guillotine traps should be baited with small pieces of Vienna sausage (Wienerwurst) or fried bacon. A small section of an ear of corn is an excellent bait if other grain is not present. The trigger wire should be bent inward to bring the bait into proper position to permit the fall to strike the rat in the neck, as shown in the illustration (fig. 2).

Other excellent baits for rats are oatmeal, toasted cheese, toasted bread (buttered), fish, fish offal, fresh liver, raw meat, pine nuts, apples, carrots, corn, and sunflower, squash, or pumpkin seeds.

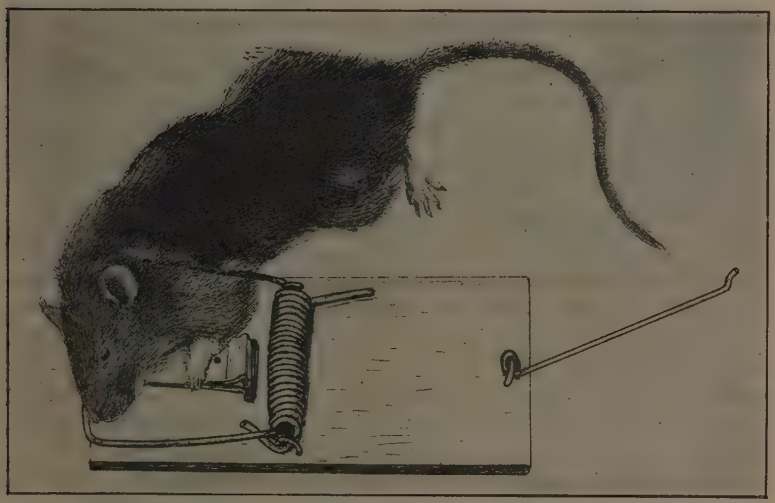

FIG. 3.—Rat caught in unbaited guillotine trap.

Broken fresh eggs are good bait at all seasons, and ripe tomatoes, green cucumbers, and other fresh vegetables are very tempting to the animals in winter. When seed, grain, or meal is used with a guillotine trap, it is placed on the trigger plate, or the trigger wire may be bent outward and the bait sprinkled under it.

The guillotine trap with wooden base and flat trigger pan is convenient for use along narrow rat runs, or at the mouth of burrows. It may be used in such places without bait (fig. 3).

Cage trap.—When rats are numerous, the large French wire cage traps can be used to advantage. They should be made of stiff, heavy wire, well reenforced. Many of those sold in hardware stores are useless, because a full-grown rat can bend the light wires apart and escape.

Cage traps should be baited and left open for several nights until the rats are accustomed to enter them to obtain food. They should then be closed and freshly baited, when a large catch may be expected, especially of young rats. As many as 25, and even more, partly grown rats have been taken at a time in one of these traps.

The writer has had excellent success by concealing a cage trap under a bunch of hay or straw, and has found by experience that a decoy rat in the trap is useful. A commission merchant in Baltimore places the baited cage trap inside of a wooden box having a hole in one end and against which the opening of the trap is fitted. The box is then covered with trash and large catches are made.

Notwithstanding the fact that sometimes a large number of rats may be taken at a time in cage traps, a few good guillotine traps intelligently used will prove more effective in the long run.

Figure-4 trigger trap.—The old-fashioned box trap set with a figure-4 trigger is sometimes useful to secure a wise old rat that refuses to be enticed into a modern trap. Better still is a simple deadfall—a flat stone or a heavy plank—supported by a figure-4 trigger. An old rat will go under such a contrivance to feed without fear.

Steel trap.—The ordinary steel trap (No. 0 or 1) may sometimes be satisfactorily employed to capture a rat. The animal is usually caught by the foot, and its squealing has a tendency to frighten other rats. The trap may be set in a shallow pan or box and covered with bran or oats, care being taken to have the space under the trigger pan free of grain. This may be done by placing a very light bit of cotton under the trigger and setting as lightly as possible. In narrow runs or at the mouth of burrows a steel trap unbaited and covered with very light cloth or tissue paper is often effective.

The best bait is usually food of a kind that the rats do not get in the vicinity. In a meat market, vegetables or grain should be used; in a feed store, meat. As far as possible, food other than the bait should be inaccessible while trapping is in progress. The bait should be kept fresh and attractive, and the kind changed when necessary. Baits and traps should be handled as little as possible. Ordinarily, traps should be frequently cleaned or smoked. The use of artificial scents, as oil of anise or rhodium, on the bait is advocated by many, but no doubt their importance has been exaggerated. The experience of the writer is not favorable to their use, but they may do some good by concealing the human odor on the trap.

Barrel trap.—About sixty years ago a writer in the Cornhill Magazine gave details of a trap, by means of which it was claimed that 3,000 rats were caught in a warehouse in a single night. The plan involved tolling the rats to the place and feeding them for several

nights on the tops of barrels covered with coarse brown paper. Afterwards a cross was cut in the paper, so that the rats fell into the barrel (fig. 4 (1)). Many variations of the plan, but few improve-

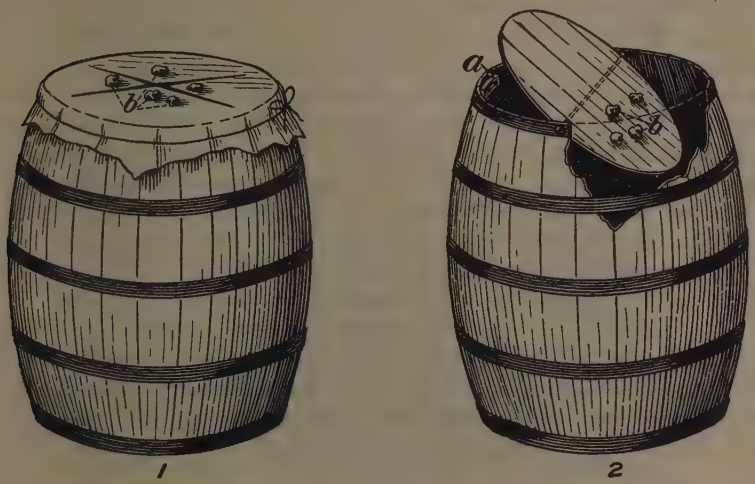

FIG. 4.—Barrel traps: 1, With stiff paper cover; 2, with hinged barrel cover; *a*, stop; *b*, baits.

ments upon it, have been suggested by agricultural writers since that time. Reports are frequently made of large catches of rats by means of a barrel fitted with a light cover of wood, hinged on a rod so as to turn with the weight of a rat (fig. 4 (2)).

Pit trap.—A modification of the barrel trap is the pit trap (fig. 5). This consists of a stout narrow box sunk in the ground so that the top is level with the rat run. It is fitted with a cover of light wood or metal in two sections, the sections fitting nicely inside the box and working independently. They turn on rods, to which they are fastened. They are weighted near the ends of the box and so adjusted that they swing easily. An animal stepping upon the cover beyond the rods is precipitated into the box, while the cover immediately swings back to its place. Besides

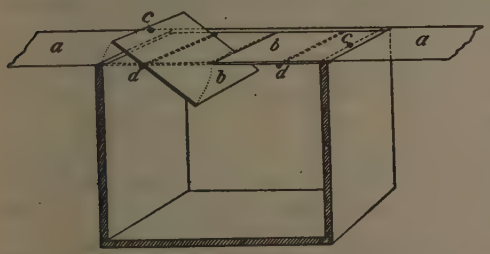

FIG. 5.—Pit trap. *aa*, Rat run; *bb*, cover; *cc*, position of weights; *dd*, rods on which covers turn.

rats, the trap is well adapted to capture larger animals, as mink, raccoons, opossums, and cats. It is especially useful to protect poultry yards, game preserves, and the like. The trap should be placed along the fence outside the yard, and behind a shelter of boards or brush that leans against the fence.

Fence and battue.—In the rice fields of the Far East the natives build numerous piles of brush and rice straw, and leave them for several days until many rats have taken shelter in them. A portable bamboo inclosure several feet in height is then set up around each pile in succession and the straw and brush are thrown out over the top, while dogs and men kill the trapped rodents. Large numbers are killed in this way, and the plan with modifications may be utilized in America with satisfactory results. A wire netting of fine mesh may be used for the inclosure. The scheme is applicable at the removal of grain, straw, or haystacks, as well as brush piles.

In a large barn near Washington, a few years ago, piles of unhusked corn shocks were left in the loft and were soon infested with rats. A wooden pen was set down surrounding the piles in turn and the corn thrown out until dogs were able to get at the rats. In this way several men and dogs killed 500 rats in a single day.

Poisons.

While the use of poison is the best and quickest way to get rid of rats, the odor from the dead animals makes the method impracticable in occupied houses. Poison, however, may be effectively used in barns, stables, sheds, cribs, and other outbuildings.

Among the principal poisons that have been recommended for killing rats are barium carbonate, strychnine, arsenic, and phosphorus.

Barium carbonate.—One of the cheapest and most effective poisons for rats and mice is barium carbonate. This mineral has the advantage of being without taste or smell. It has a corrosive action on the mucous lining of the stomach and is dangerous to larger animals if taken in sufficient quantity. In the small doses fed to rats and mice it would be harmless to domestic animals. Its action upon rats is slow, and if exit is possible they usually leave the premises in search of water. For this reason the poison may frequently, though not always, be used in houses without disagreeable consequences.

Barium carbonate may be fed in the form of dough composed of four parts of meal or flour and one part of the mineral. A more convenient bait is ordinary oatmeal with about one-eighth of its bulk of the mineral, mixed with water into a stiff dough. A third plan is to spread the barium carbonate upon fish, toasted bread (moistened), or ordinary bread and butter. The prepared bait should be placed in

rat runs, about a teaspoonful at a place. If a single application of the poison fails to kill or drive away all rats from the premises, it should be repeated with a change of bait.

Strychnine.—Strychnine is too rapid in action to make its use for rats desirable in houses, but elsewhere it may be employed effectively. Strychnia sulphate is the best form to use. The dry crystals may be inserted in small pieces of raw meat, Vienna sausage, or toasted cheese, and these placed in rat runs or burrows; or oatmeal may be moistened with a strychnine sirup, and small quantities laid in the same way.

Strychnine sirup is prepared as follows: Dissolve a half ounce of strychnia sulphate in a pint of boiling water; add a pint of thick sugar sirup and stir thoroughly. A smaller quantity may be prepared with a proportional quantity of water and sirup. In preparing the bait it is necessary to moisten all the oatmeal with the sirup. Wheat and corn are excellent alternative baits. The grain should be soaked overnight in the strychnine sirup.

Arsenic.—Arsenic is probably the most popular of the rat poisons, owing to its cheapness; yet our experiments prove that, measured by the results obtained, arsenic is dearer than strychnine. Besides, arsenic is extremely variable in its effect upon rats; and if the animals survive a first dose it is very difficult to induce them to take another.

Powdered white arsenic (arsenious acid) may be fed to rats in almost any of the baits mentioned under barium carbonate and strychnine. It has been used successfully when rubbed into fresh fish or spread on buttered toast. Another method is to mix twelve parts by weight of corn meal and one part of arsenic with whites of eggs into a stiff dough.

An old formula for poisoning rats and mice with arsenic is the following, adapted from an English source:

Take a pound of oatmeal, a pound of coarse brown sugar, and a spoonful of arsenic. Mix well together and put the composition into an earthen jar. Put a tablespoonful at a place in runs frequented by rats.

Phosphorus.—For poisoning rats and mice, phosphorus is used almost as commonly as arsenic, and undoubtedly it is effective when given in an attractive bait. The phosphorus paste of the drug stores is usually dissolved yellow phosphorus, mixed with glucose or other substances. The proportion of phosphorus varies from one-fourth of 1 per cent to 4 per cent. The first amount is too small to be always effective and the last is dangerously inflammable. When homemade preparations of phosphorus are used, there is much danger of burning the person or of setting fire to crops or buildings. In the Western States many fires have resulted from putting out

homemade phosphorus poisons for ground squirrels, and entire fields of ripe grain have been destroyed in this way. Even with the commercial pastes the action of sun and rain upon them changes the phosphorus and leaches out the glucose until a highly inflammable residue is left.

It is often claimed that when phosphorus is eaten by rats or mice it dries up or mummifies the body so that no odor results. The statement has no foundation in fact. Equally misleading is the statement that rats poisoned with phosphorus do not die on the premises. Owing to its slower operation, no doubt a larger proportion escape into the open before dying than when strychnine is used.

The Biological Survey does not recommend the use of phosphorus as a poison for rodents.

Caution.—In the United States there are few laws which prohibit the laying of poisons on lands owned or controlled by the poisoner. Hence it is all the more necessary to exercise extreme caution to prevent accidents. In several States notice of intention to lay poison must be given to persons living in the neighborhood. Poison for rats should never be placed in open or unsheltered places. This applies particularly to strychnine or arsenic on meat.

Poison in poultry houses.—For poisoning rats in buildings and yards occupied by poultry the following method is recommended: Two wooden boxes should be used, one considerably larger than the other, and each having two or more holes in the sides large enough to admit rats. The poisoned bait should be placed on the bottom and near the middle of the smaller box, and the larger box should then be inverted over the other. Rats thus have free access to the bait, but fowls are excluded.

Domestic Animals.

Among domestic animals employed to kill rats are the dog, cat, and ferret.

Dogs.—The value of dogs as ratters can not be appreciated by persons who have had no experience with a trained animal. The ordinary cur and the larger breeds of dogs seldom develop the necessary qualities for ratters. Small Irish, Scotch, and fox terriers when properly trained are superior to other breeds, and under favorable circumstances may be relied upon to keep the farm premises reasonably free from rats.

Cats.—However valuable cats may be as mousers, few of them learn to catch rats. The ordinary house cat is too well fed and consequently too lazy to undertake the capture of an animal as formidable as the brown rat. Birds and mice are much more to its liking.

Ferrets.—Tame ferrets, like weasels, are inveterate foes of rats, and can follow the rodents into their retreats. Under favorable circumstances they are useful aids to the rat catcher, but their value is greatly overestimated. For effective work they require experienced handling and the additional services of a dog or two. Dogs and ferrets must be thoroughly accustomed to each other, and the former must be quiet and steady instead of noisy and excitable. The ferret is used only to bolt the rats, which are killed by the dogs. If unmuzzled ferrets are sent into rat retreats, they are apt to make a kill and then lie up after sucking the blood of their victim. Sometimes they remain for hours in the burrows or escape by other exits and are lost. There is danger that these lost ferrets may adapt themselves to wild conditions and become a pest by preying upon poultry and birds.

Fumigation.

Rats may be destroyed in their burrows in the fields and along river banks, levees, and dikes by carbon bisulphid. A wad of cotton or other absorbent material is saturated with the liquid and then pushed into the burrow, the opening being packed with earth to prevent the escape of the gas. All animals in the burrow are asphyxiated. Fumigation in buildings is not so effective, because it is difficult to confine the gases. Moreover, when effective, the odor from the dead rats is highly objectionable in occupied buildings.

Chlorin, carbon monoxid, sulphur dioxid, and hydrocyanic acid are the gases most used for destroying rats and mice in sheds, warehouses, and stores. Each is effective if the gas can be confined and made to reach the retreats of the animals. Owing to the great danger from fire incident to burning charcoal or sulphur in open pans, a special furnace provided with means for forcing the gas into the compartments of vessels or buildings is generally employed.

Hydrocyanic-acid gas is effective in destroying all animal life in buildings. It has been successfully used to free elevators and warehouses of rats, mice, and insects. However, it is so dangerous to human life that the novice should not attempt fumigation with it, except under careful instructions. Directions for preparing and using the gas may be found in a publication entitled Hydrocyanic-acid Gas against Household Insects, by Dr. L. O. Howard.[a]

Carbon monoxid is rather dangerous, as its presence in the hold of a vessel or other apartment is not manifest to the senses, and fatal accidents have occurred during its employment to fumigate vessels.

Chlorin gas has a strong bleaching action upon textile fabrics, and for this reason can not be used in many situations.

[a] Circular 46, Bureau of Entomology, U. S. Dept. of Agric., 1907.

Sulphur dioxid also has a bleaching effect upon textiles, but less marked than that of chlorin and ordinarily not noticeable with the small percentage of the gas it is necessary to use. On the whole, this gas has many advantages as a fumigator and disinfectant. It is used also as a fire extinguisher on board vessels. Special furnaces for generating the gas and forcing it into the compartments of ships and buildings are on the market, and many steamships and docks are now fitted with the apparatus.

Micro-organisms.

Several micro-organisms, or bacteria, have been exploited in Europe and America for destroying rats. A number are on the market in the United States. With the aid of the Biochemic Division of the Bureau of Animal Industry, the Biological Survey has made laboratory and field experiments with some of them, and has also received many reports from others who have tried the cultures in a practical way. The results are by no means uniform, although the majority are negative. The cultures tested by the Survey have given poor results.

The chief defects to be overcome before the cultures can be recommended for general use are:

1. The virulence is not great enough to kill a sufficiently high percentage of rats that eat food containing the micro-organisms.

2. The virulence decreases with the age of the cultures. They deteriorate in warm weather and in bright sunlight.

3. The diseases resulting from the micro-organisms are not contagious and do not spread by contact of diseased with healthy animals.

4. The comparative cost of the cultures is too great for general use. Since they have no advantages over the common poisons, except that they are usually harmless to man and other animals, they should be equally cheap; but their actual cost is much greater. Moreover, considering the skill and care necessary in their preparation, it is doubtful if the cost can be greatly reduced.

Organized Efforts to Destroy Rats.

The necessity of cooperation and organization in the work of rat destruction should not be overlooked. To destroy all the animals on the premises of a single farmer in a community has little permanent value, since they are soon replaced from near-by farms. If, however, the farmers of an entire township or county unite in efforts to get rid of rats, much more lasting results may be attained. If continued from year to year, such organized efforts are very effective.

Cooperative efforts to destroy rats have taken various forms in different localities. In cities municipal employees have occasionally been set at work hunting rats from their retreats, with at least temporary benefit to the community. Thus, in 1904, at Folkestone, England, a town of about 25,000 inhabitants, the corporation employees, helped by dogs, in three days killed 1,645 rats.

Side hunts in which rats are the only animals that count in the contest have sometimes been organized and successfully carried out. At New Burlington, Ohio, a rat hunt took place November 26, 1866, in which each of the two sides killed over 8,000 rats, the beaten party serving a Thanksgiving banquet to the winners.

There is danger that organized rat hunts will be followed by long intervals of indifference and inaction. This may be prevented by offering prizes covering a definite period of effort. Such prizes accomplish more than municipal bounties, because they secure a friendly rivalry which stimulates the contestants to do their utmost to win.

In England and some of its colonies contests for prizes have been organized to promote the destruction of the European house sparrow, but many of the so-called sparrow clubs are really sparrow and rat clubs, for the destruction of both pests is the avowed object of the organization. A sparrow club in Kent, England, secured the destruction of 28,000 sparrows and 16,000 rats in three seasons by the annual expenditure of but £6 ($29.20) in prize money. Had ordinary bounties been paid for this destruction, the tax on the community would have been about £250 (over $1,200).

SUMMARY OF RECOMMENDATIONS.

The following are important aids in limiting the numbers of rats and reducing the losses from their depredations:

1. Protection of our native hawks, owls, and smaller predatory mammals—the natural enemies of rats.

2. Greater cleanliness about stables, markets, grocery stores, warehouses, courts, alleys, and vacant lots in cities and villages, and like care on farms and suburban premises. This includes the storage of waste and garbage in tightly covered vessels and the prompt disposal of it each day.

3. Care in the construction of buildings and drains, so as not to provide entrance and retreats for rats, and the permanent closing of all rat holes in old houses and cellars.

4. The early thrashing and marketing of grains on farms, so that stacks and mows shall not furnish harborage and food for rats.

5. Removal of outlying straw stacks and piles of trash or lumber that harbor rats in the fields.

6. Rat-proofing of warehouses, markets, cribs, stables, and granaries for storage of provisions, seed grain, and feedstuffs.

7. Keeping effective rat dogs, especially on farms and in city warehouses.

8. The systematic destruction of rats, whenever and wherever possible, by (*a*) trapping, (*b*) poisoning, and (*c*) organized hunts.

9. The organization of rat clubs and other societies for systematic warfare against rats.

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